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METHOD FOR APPLYING AN IN-MOLD COATING ON A SURFACE AREA OF
AN INJECTION MOULDED SUBSTRATE

5

FIELD OF THE INVENTION

The present invention relates to a method for coating a molded article or substrate with an in-mold composition, wherein the flow and thus the thickness of the in-mold composition onto the substrate can be selectively controlled. Importantly, desired areas of molded articles can be preferentially coated with in-mold coating compositions by controlling the thickness or depth of various sections of the substrate. Advantageously, the method of the present invention can be utilized to mold articles of relatively complex shape or design which have an in-mold coating thereon having a uniform or desired appearance.

In one embodiment of the present invention, a molded article is provided with an area of increased relative thickness at the location of in-mold coating injection in order to encourage or promote in-mold coating flow.

In yet another embodiment of the present invention, a molded article or substrate is provided with at least one runner section or preferred flow channel to promote in-mold coating flow over the surface of a substrate.

Still another embodiment of the present invention involves providing a molded article or substrate with an in-mold coating containment flange which acts as a barrier and prevents the in-mold

coating from leaking or seeping off of the desired surface and out of the mold cavity. The in-mold coating containment flange extends substantially completely around the perimeter of a molded substrate surface where the in-mold coating has been applied thereto.

5

BACKGROUND OF THE INVENTION

Molded thermoplastic and thermoset articles, such as those made from polyolefins, polycarbonate, polyester, polyethylene, polypropylene, polystyrene and polyurethanes, are utilized in numerous applications including those for the automotive, marine, recreation, construction, office products, and outdoor equipment industries. For example, automotive industry applications include body panels, wheel covers, bumpers, head and tail lamps, fenders, hoods, and dashboards.

15 Use of the molded articles is not without problem, as the surface quality may not meet required standards, such as durability, chemical resistance, and weather resistance. In many instances, the molded thermoplastic articles may need to be coated to satisfy the above-noted requirements or to facilitate paint adhesion.

20 Countless methods have been developed to apply various coatings to the molded articles to improve the surface characteristics thereof.

Previously, molded work pieces were formed in a mold, the molded product removed, and a coating was then applied on the surface of the molded work piece by a coating process, such as a surface treatment, primer coating, top coating, painting, etc. Hence
5 the foregoing methods required an additional step to achieve a finished surface on a work piece, i.e. treating the surface of the pre-formed work piece prior to applying a paint or coating. These methods required additional steps and increased costs of preparing the molded work piece surface.

10 It became desirable, therefore, to have a method by which a coating could be applied to a work piece in the mold, resulting in a coated work piece the surface of which would be finished and suitable for use as is in an end use application, or which would require less or no surface preparation treatment than heretofore
15 utilized.

The application of in-mold coatings (IMC) to thermoplastic or thermoset materials to provide generally smooth surfaces, improve durability and other surface properties, and to reduce or eliminate substrate porosity is known. A number of in-mold coating methods
20 have been employed for applying coatings, in compression molding methods or injection molding methods employing molding materials of thermosetting resins, such as SMC (sheet molding compound)

and BMC (bulk molding compound) (e.g., U.S. Pat. Nos. 4,076,788; 4,081,578; 4,331,735; 4,366,109; and 4,668,460).

Heretofore, the in-mold coatings which have been applied to molded articles typically covered the entire surface of the article.

5 The coverage of the coating was controlled by only the amount of coating applied, such as in the case of an undershot, or the physical boundaries of the mold cavity.

SUMMARY OF THE INVENTION

10 An improved method for applying in-mold coatings has been developed, whereby molded articles can be preferentially coated in desired area, and depth of coating can be regulated by selectively controlling the thickness of sections of the article.

The present invention relates to a method for preferentially
15 in-mold coating a molded article or substrate in at least one predetermined area based upon the thickness or depth of the article. A first composition is molded into an article or substrate in a mold, preferably by injection molding techniques known in the art. A second composition is applied to the substrate in-mold, wherein the
20 second composition is directed to at least one predetermined area of the substrate based on the compressibility thereof.

Molded substrates often have complex designs or configurations and heretofore, it has been difficult or impossible to

produce an in-mold coated article which has been properly or fully coated to desired specifications.

Advantageously, it has been found that the flow of in-mold coating over an article can be effectively controlled, whereby the coating can be channeled or routed so that the coating on the substrate surface conforms to design specifications. The in-mold coatings are preferably channeled by providing the substrate with areas of varying thickness or depth below the surface to be coated. It has been found that substrate areas of greater depth promote in-mold coating flow relative to less thick areas. The present invention also teaches a method for controlling the thickness of an in-mold coating on a substrate.

The present invention provides a method for producing molded articles with coatings in predetermined areas which are suitable for use as-is in an end use application or which require minimal or no surface post-treatment.

A further object of the present invention is to eliminate the need of applying additional paint or other surface treatment coatings to a surface of a pre-formed work piece.

Yet another object of the present invention is to provide a work piece having an appearance in-mold coating thereon, which has paint-like properties, such as high gloss, hardness, good adhesion and good weatherability.

A further object of the present invention is to provide a work piece having an in-mold coating thereon, which has good flow and coverage during molding, good adhesion, uniform color, durability, weather resistance, good surface qualities, and good paintability.

5 In one embodiment of the present invention, a molded article is provided with an area of increased relative thickness at the location of in-mold coating injection in order to encourage or promote in-mold coating flow.

10 In yet another embodiment of the present invention, a molded article or substrate is provided with at least one runner section or preferred flow channel to promote in-mold coating flow over the surface of a substrate.

15 Still another embodiment of the present invention involves providing a molded article or substrate with an in-mold coating containment flange which acts as a barrier and prevents the in-mold coating from leaking or seeping out of the mold cavity. The in-mold coating containment flange extends substantially completely around the perimeter of a coated molded substrate surface.

20

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and other features and advantages will become apparent by reading the detailed

description of the invention, taken together with the drawings,
wherein:

FIG. 1 is a side view of one embodiment of a molding
apparatus suitable for practicing the method of the present
5 invention.

FIG. 2 is a cross section through a vertical elevation of a
mold cavity.

FIG. 3 is a top view of a molded substrate prior to being
coated with an in-mold coating. The substrate is shown having an
10 area of increased thickness in order to promote and/or channel in-
mold coating flow.

FIG. 4 is a front view of the substrate shown in FIG. 3.

FIG. 5 is a back view of the substrate shown in FIG. 3,
wherein areas of varying depth are distinctly shown.

15 FIG. 6 is a side view of a molded door panel. The door panel
is provided with areas of varying depth in order to channel in-mold
coating flow over the surface so that the same is coated in desired
areas in order to meet a predetermined standard.

20 FIG. 7 is the substrate of FIG. 4 having an in-mold coating on
a show surface thereof.

FIG. 8 is the substrate of FIG. 4 having an in-mold coating
located substantially only in a runner section of the show surface.

FIG. 9 is a front elevation view of a substantially flat molded plaque with a substantially flat show surface. The location of runner sections and thickness are shown for the benefit of the viewer.

FIG. 10 is a front view of a molded substrate with areas of varying thickness illustrated.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to producing a molded article or substrate having a coating bonded thereto. The coating is present on the surface of the substrate in a predetermined area or areas. In-mold coating thickness can also be controlled by the method of the present invention.

The method of the present invention provides a process for controlling the flow of an in-mold coating so that it can be channeled or routed on a substrate to result in a coating having a uniform thickness or appearance on a large or complex shape. The in-mold coating can be channeled to coat an entire surface of a substrate or only selected areas thereof.

The method of the present invention can generally be practiced on any molding apparatus such as injection molders capable of producing a molded article or substrate of a first composition and then coating the article or substrate with a second composition, i.e. an in-mold coating.

Making reference now to the drawings wherein like numerals indicate like or corresponding parts throughout the several figures, a molding apparatus suitable for the practice of the present invention is shown in FIG. 1, and is generally designated 10.

5 Molding apparatus 10 includes a first mold half 20 which preferably remains in a stationary or fixed position relative to a second moveable mold half 30. FIG. 1 shows the mold halves in an open position. The first mold half and second mold half are adapted to slidingly mate, or nest, thereby forming a mold cavity 40
10 therebetween as shown in at least FIG. 2. The mold halves mate along surfaces 24 and 34 (FIG. 1) when the molding apparatus is in the closed position, forming a parting line 42 (FIG. 2) therebetween.

The moveable mold half 30 reciprocates generally along a horizontal axis relative to the first or fixed mold half 20 by action of
15 a clamping mechanism 70 with a clamp actuator 72 such as through a hydraulic, mechanical, or electrical actuator as known in the art. The clamping pressure exerted by the clamping mechanism 70 should have an operating pressure in excess of the pressures generated or exerted by the first composition injector and the
20 second composition injector. The pressure exerted by the clamping mechanism ranges generally from about 2,000 to about 15,000, desirably from about 4,000 to about 12,000, and preferably from

about 6,000 to about 10,000 pounds per square inch (psi) of mold surface.

In FIG. 2, the mold halves 20 and 30 are shown in a closed position, abutted or mated along parting line 42 at face surfaces 24 and 34. As illustrated, the mold cavity is shown in cross section. It is readily understood by those skilled in the art that the design of the cavity can vary greatly in size and shape according to the end product to be molded. The mold cavity generally has a first surface 44 on the first mold half, upon which a show surface of an article will be formed, and a corresponding back side or opposite second surface 46 on the second mold half. The mold cavity also contains separate orifices to allow the first and second composition injectors to inject their respective compositions thereinto. The location of the injectors and injection orifices thereof can vary from apparatus to apparatus, and part to part, and can be based on factors such as efficiency, functionality, or desire of the mold designer.

As shown in FIG. 1, the first composition injector 50 is a typical injection molding apparatus which is well know to those of ordinary skill in the art and is capable of injecting a thermoplastic or thermosetting composition, generally a resin or polymer, into the mold cavity. The first composition injector is shown in a "backed off" position, but it is readily understood that the same can be moved to a horizontal direction so that nozzle or resin outlet 58

mates with mold half 20 and can inject into mold cavity 40. For purposes of illustration only, the first composition injector in FIG. 1 is a reciprocating-screw machine wherein a first composition can be placed in hopper 52 and rotating screw 56 moves the composition through the heated extruder barrel 54, wherein the material is heated above its melting point. As the material collects in the end of the barrel, the screw acts as an injection ram and forces it through the nozzle 58 into the mold cavity 40. The nozzle generally has a non-return valve at the nozzle or screw tip to prevent the backflow of material into the screw.

The first composition injector is not meant to be limited to the embodiment shown in FIG. 1 but can be any apparatus capable of injecting a thermoplastic composition into the mold cavity. Suitable injection molding machines are available from Cincinnati Milacron, Battenfeld, Engel, Husky, Boy and others.

The present invention for selectively controlling the flow of in-mold coatings can be practiced on generally any thermoplastic substrates which can be injection molded. Suitable thermoplastic substrates, include but are not limited to polyethylene terephthalate (PET), nylon, acrylonitrile butadiene styrene (ABS), polystyrene, polycarbonate, acrylic, acetal, polyolefins such as polyethylene and polypropylene, and polyvinyl chloride (PVC). The

foregoing list is not meant to be exhaustive but only illustrative of the various materials useful in the practice of the invention.

It has been found that a surface of the substrate can be selectively coated with in-mold coatings in predetermined areas by
5 controlling or modifying the thickness or depth of the substrate. When utilized in the present invention, thickness or depth is defined as a distance, girth, or dimension from one surface to the opposite surface of the substrate. The method of the present invention is generally concerned with the depth between two surfaces, the first
10 being a surface to which an in-mold mold coating is selectively directed or applied, commonly referred to as a show or appearance surface, and the back surface that is substantially the opposite side of the substrate. The in-mold coating may but does not necessarily cover the entire show surface. For example, in FIG. 3 thickness
15 refers to the distance from show surface 82 of a substrate to the backside or opposite surface 84. As shown in FIG. 3, the thickness between the show surface and back side of the substrate can vary.

Each substrate of the present invention inherently has a compressibility factor or percentage, wherein at a given temperature
20 each specific substrate is compressible to a certain calculable percentage. Therefore, even though a molded article or substrate has a single compressibility ratio, a first area of a substrate which is thicker relative to a second area of the substrate will be able to

compress a greater thickness or distance than the second substrate. For example, substrate "A" has a compressibility ratio of 20 percent at a certain temperature. Therefore, a portion of substrate "A" which has a thickness of 2.0 cm can compress 0.4 cm, whereas a
5 portion of the substrate which has a thickness of 1.0 cm can only compress 0.2 cm at the given temperature.

The above described substrate compressibility can be utilized to selectively coat predetermined areas of a substrate. Substrate compressibility can also be utilized to effectively direct the flow of
10 an in-mold coating into certain areas or pathways of a substrate.

In-mold coatings can be applied to a substrate in numerous ways well known to those of ordinary skill in the art. The present invention is not meant to be limited to the following example. As shown in FIG. 2, an in-mold coating or second composition injector
15 60 has a nozzle 62 which is located on the molding apparatus in a suitable location such as on mold half 30. A first quantity of a first composition 80 is injected into a mold cavity to a desired predetermined level, forming a substrate, work piece, or article, such as plaque 100 shown in the views of FIGS. 3-5. As shown in
20 FIG. 3, the substrate has at least a show surface 82 and a back side 84. An in-mold coating composition 90 is then injected into the mold cavity from in-mold coating injector 60. The in-mold coating is injected through at least one nozzle 62 onto the show

surface side of the substrate at a location such as 104 on tab 102 as shown in FIG. 4.

It is important to note that the mold is not opened or unclamped before and/or during in-mold coating application, that is, the mold halves maintain a parting line and generally remain a substantially fixed distance from each other while both the first and second compositions are injected into the mold cavity as described herein.

The in-mold coating composition spreads out, disperses, or radiates from the point of injection 104 onto the show surface of the substrate. The point of injection of the in-mold coating onto the substrate will depend on the location of the in-mold coating injector and nozzle thereof in the molding apparatus. Accordingly, the point of injection of the in-mold coating can be located substantially anywhere on the substrate show surface and is not limited to the locations shown in the drawings of the present invention.

One embodiment of the present invention relates to a method for directing or channeling the flow of an in-mold coating on a substrate. Unexpectedly, it has been found that substrate compressibility can be utilized to direct in-mold coating flow for in-mold coating systems which are conducted "closed clamp", wherein the mold halves remain abutted or closed at least during the time between injection of a first composition and an in-mold

coating composition. That is, the parting line between the mold halves is not separated during the molding operation in which an in-mold coated substrate is produced. When mold halves 20, 30 are closed or joined, a mold cavity 40 is formed therebetween. The mold cavity has a configuration with a specific defined volume. A predetermined amount of a first composition which will produce a desired substrate is injected into the mold cavity. By the term predetermined, it is understood by one of ordinary skill in the art that through the control of variables of the molding process, a calculated amount of material that will produce a desired substrate can be experimentally determined. After the first composition has been injected into the mold cavity and has cooled below the melt point or otherwise reached a temperature sufficient to accept or support an in-mold coating, a predetermined amount of in-mold coating is injected from injector unit 60 through at least one nozzle onto an injection point of the substrate, preferably on a show surface thereof. The coating is injected at a pressure that ranges generally from about 500 to about 5,000, desirably from about 1,000 to about 4,500, and preferably from about 2,000 to about 4,000 pounds per square inch (psi). The injection pressure promotes the spread of the in-mold coating away from the nozzle. The in-mold coating spreads from the nozzle between a mold surface and a surface of the substrate.

Unexpectedly, it has been found that by varying the thickness or depth of the resin of the substrate below the surface to be coated, the in-mold coating can be routed to preferred areas of the substrate, and contained therein, if desired. For example, if a mold cavity is designed so that a substrate has a constant thickness under an area to be in-mold coated, the in-mold coating will spread out from the location of injection in a substantially radial, even, or constant manner. Under the same relative conditions, if a substrate is formed having areas which vary in thickness under the surface area to be coated, the in-mold coating can be channeled to flow in area(s) of greater relative thickness. Thus, the depth of the coating can also vary on the coated surface. It has been demonstrated, as stated hereinabove, that the compressibility of the substrate allows a substrate area having a greater depth relative to a second area to compress more and better accommodate in-mold coating flow and promote migration thereof.

In one embodiment of the present invention, a substrate is provided with an area or section of increased thickness around the point or location where the in-mold coating is injected onto the substrate in order to promote in-mold coating flow. By increased thickness, it is to be understood that the thickness of the substrate around the in-mold coating injection location is greater than at least one other area or section of the substrate. As shown in FIG. 5,

plaque 100 is shown with a tab area 110 at a location of in-mold coating injection. The tab area thickness can be varied to enhance channeling of the in-mold coating. Tab section 104 in FIG. 4 includes a thin section or in-mold coating containment tab flange 102 which prevents the in-mold coating from flowing out of the mold cavity. The concept of the containment flange will be further explained hereinbelow. The relatively thick tab area promotes in-mold coating flow from the in-mold coating nozzle onto the show surface 80 of the substrate. The in-mold coating will tend to avoid tab or other substrate sections of minimal or lesser thickness.

In a further embodiment of the present invention, a substrate is provided with at least one "runner" section, preferential flow channel, or area to promote in-mold coating flow on a substrate. A runner section is an area which is relatively thicker than another area adjacent thereto, wherein the in-mold coating can be preferably routed to flow. Advantageously, runner sections can be provided on substrates of complex design or which were previously difficult to coat. A runner section generally is located in an area on the substrate beginning in the region of the point of injection of the in-mold coating and extending away therefrom to a predetermined point or terminus on the substrate. For example, FIG. 5 has a runner section 106 extending from and including the tab area to substantially the bottom end 107 of the plaque. FIG. 6 shows a

door panel having three runner sections 120. By providing a substrate with at least one runner section, in-mold coatings can be effectively routed or channeled to cover desired areas of a substrate.

5 Depending on the amount of in-mold coating injected into the mold cavity, the show surface substrate having a runner section can be completely coated or coated only in certain areas or sections such as the runner areas. The amount of coating applied and thickness thereof can vary from part to part.

10 The depth of the runner section can vary depending on the substrate to be coated and design specifications. A substrate can have a runner section extending from an area of in-mold coating injection which is so relatively thick that all of the in-mold coating application to the substrate surface will substantially remain in the
15 runner section. Therefore, as can be imagined, many unique effects can be created by utilizing runner sections. Frequently, it is desirable to completely coat the show surface with an in-mold coating. It is often difficult to coat a substrate having a complex or detailed shape. Runner sections can be used to effectively in-mold
20 coat these substrates by channeling in-mold coating to the previously hard to coat areas. For example, a runner section can be utilized to channel a coating to a distal part of a substrate surface. The runner section thickness can be gradually decreased such as in

a direction away from the point of injection as needed, or even separated or divided into more than one runner section to accomplish a desired effect or coating.

5 In yet another embodiment of the present invention, a molded substrate or article is provided with an in-mold coating containment flange 130. As shown in at least FIG. 4, coating containment flange preferably extends completely around the perimeter of a substrate, specifically plaque 100. Often, it is desirable to substantially coat the show surface of a substrate with an in-mold
10 coating. The containment flange 130 acts a barrier and prevents the in-mold coating from leaking or seeping out of the mold cavity and potentially blowing out of the parting line between the mold halves.

As shown in at least FIG. 3, flange 130 is generally offset or
15 formed in a plane below the plane of the show surface 82. Thus, the show surface has an edge or border 83 which transitions into flange 130. Show surface edge 83 drops off into a wall at an angle of about 90° relative to the show surface. Substrate wall 86 terminates at flange portion 130, wherein flange portion extends at
20 an angle of about 90° in relation to wall 86. It is believed that the relatively sharp angles between show surface and flange 130 as well as the relative incompressibility of the thin flange act as a

substantial barrier to coating flow, and thus prevent the coating from leaving the show surface. The flange generally has a thickness less than the thinnest portion or area of the substrate. As shown in FIG. 3, containment flange 130 is thinner than section 5 112, the relatively thinnest section of the substrate. The in-mold coating containment flange encompasses substantially the entire perimeter of a substrate surface that will be or is coated. The flange has a width of at least generally about 0.225 to about 0.176, desirably about 0.175 to about 0.076, and preferably about 0.075 10 to about 0.045 inches. As stated above, the main purpose of the flange is to prevent the in-mold coating from leaving the target surface of the substrate and stopping the coating from giving entrance to the mold parting line.

As shown in FIG. 7, the in-mold coating 90 covers the entire 15 show surface of the molded substrate. Due to the configuration of the molded substrate as well as other molding variables, the coating 90 does not cover or coat the containment flange 130. However, it is permissible for the in-mold coating to coat or partially coat the containment flange. Due to the design of the containment flange, 20 generally less than about 10%, desirably less than 5%, and preferably less than 1% by weight of the in-mold coating covers or coats the containment flange. The containment flange is free of any other substrate material on the distal edge thereof. This is,

there is no other substrate material or outer edge between the containment flange and the mold cavity parting line.

The process of the present invention utilizes in-mold coatings, many of which are available commercially. Such coatings include
5 GenGlaze® and Stylecoat®, acrylic based appearance in-mold coatings available from Omnova Solutions Inc. of Fairlawn, Ohio, as well as others. These and other coatings are well known to the art. Suitable in-mold coatings are found in U. S. Patent No. 5,777,053, herein incorporated by reference. The main advantage of acrylic
10 coatings is the high degree of resistance to thermal and photooxidation and to hydrolysis, giving coatings that have superior color retention, resistance to embrittlement and exterior durability. Low-molecular weight acrylic resins having an average functionality of two to three and containing few molecules that are nonfunctional or only
15 monofunctional, are useful in the present invention. Epoxy resins are also useful as in-mold coatings in the present invention. A principal use of epoxy resins is as a component in two-package primer coatings. One part contains the epoxy resin and the other part contains a polyfunctional amine. Amine-terminated polyamides,
20 sometimes called amido-amines, are widely used. A preferred acrylic resin is an epoxy-based oligomer having at least two acrylate groups and at least one copolymerizable ethylenically unsaturated monomer,

and at least one copolymerizable monoethylenically unsaturated compounds having a -CO-, group and a -NH₂-, NH, and or -OH- group.

The present invention also contemplates the use of other resin coatings, such as alkyds, polyesters, urethane systems, amino resins,
5 phenolic resins, and silicone resins. See e.g., Kirk Othmer, Encyclopedia of Chemical Technology, Vol. 6 (4th ed. 1993) at pp. 676-690.

In-mold coatings comprising five components, namely

- 1) a saturated aliphatic polyester intermediate urethane
- 10 2) an aliphatic polyether
- 3) an aliphatic or cycloaliphatic portion (meth)acrylate
- 4) hydroxy alkyl (meth)acrylates
- 5) vinyl substituted aromatics

have been found to have particular utility in the practice of
15 this invention. In-mold coating compositions are prepared as follows.

The polyester urethane acrylate is mixed with the vinyl substituted aromatic monomers such as styrene, the saturated aliphatic or cycloaliphatic (meth) acrylates such as isobornyl acrylate, and the hydroxyalkyl methacrylate, such as hydroxypropyl methacrylate.

20 After these compounds are mixed, fillers and additives, such as cure inhibitors, light stabilizers, lubricants, etc., are added and mixed. The free radical generating initiator is added last. The polyacrylate ester of a polyol can be present in the polyester urethane acrylate from the

supplier. This in-mold coating composition is clear after curing.

Any of the coatings contemplated for use in the present invention can be colored by utilizing a pigment, a colorant, etc., in a desired or effective amount to yield a desired color, tint, hue, or opacity. Pigments, pigment dispersions, colorants, etc. are well known to the art and include, for example, graphite, titanium dioxide, carbon black, phthalocyanine blue, phthalocyanine red, chromium and ferric oxides, aluminum or other metal flake, and the like.

When an in-mold coating having a specific color is desired, one or more pigments, colorants, etc., can be utilized in suitable amounts. As known to the art, often times various pigments or colorants are added with a carrier, for example, a polyester, so that they can be easily blended. Any suitable mixing vessel can be utilized, and the various components and additives mixed until the compounds are blended. Even if pigments are not contained in the blend, the mixture at this point is not clear.

All of the above-described in-mold coating compositions that may be utilized in the present invention may contain other additives and fillers, etc., in amounts known to the art. For example, various cure inhibitors such as benzoquinone, hydroquinone, methoxyhydroquinone, p-t-butylcatechol, and the like, can also be utilized. Other additives may include an accelerator, such as cobalt octoate. Other classes of accelerators include zinc, or other metal

carboxylates. Various light stabilizers can also be utilized such as, for example, the various hindered amines (HALS), substituted benzophenones, and substituted benztriazoles, and the like. Lubricants and mold release agents are generally utilized with specific examples including various metal stearates, such as zinc stearate or calcium stearate or phosphonic acid esters. Reinforcing fillers, such as talc, can be utilized. Other additives include hardeners, thixotropes, such as silica, and adhesion agents, such as polyvinyl acetate.

EXAMPLES

Example 1

A mold used to produce the plaque 200 shown in FIG. 9 was made. The mold cavity width is 12.0 inches. The mold cavity length is 20.5 inches. The mold has a hydraulic mold gate located in the center of the cavity for injection of a substrate. The mold has a tapered tab for the introduction of the IMC onto the part surface. The tab is located at the edge portion of the mold. The tab and Section A have thicknesses of 0.120 mils. Section B is 0.100 mils thick. Section C is 0.080 mils thick. Section D is 0.060 mils thick. As shown in FIG. 9, the plaque has four panels in a horizontal plane on the left side of the part and four panels in a vertical plane on the right side of the part. The panels on the horizontal plane on the right side of the part measure 6.0 inches long and 5.125 wide. The

panels on the vertical plane measure 1.50 inches wide and 20.5 inches long. The plaque does not have an in-mold coating containment flange. The mold was placed in an 850 ton Cincinnati Milacron Vista injection molding machine. ABS resin heated to a temperature of 480°F was injected into the mold cavity thus producing the part shown in FIG. 9 having sections with the above-described dimensions. FIG. 9 is a front view of the plaque. As stated above, the various sections A-D represent varying thicknesses of the plaque in the defined areas. The front of the plaque shown in FIG. 9 is a smooth surface and thus, the backside of the plaque shows the various thickness contour variations. After a hold time of approximately 120 seconds, an in-mold coating, Stylecoat® was injected through the tab portion of the plaque onto the front surface of the plaque. The chart below details how the in-mold coating flowed onto the different sections of the plaque.

Amount of IMC	% of Full IMC Shot	Section A % Fill/mils*	Section B % Fill/mils*	Section C % Fill/mils*	Section D % Fill/mils*
.32 cubic inches	25	75/1	15/.5	0/0	0/0
.64 cubic inches	50	98/3	85/1.6	10/.6	0/0

* 1 mil = 0.001 inch

It was determined from the part surface area to be coated, and the desired coating thickness, that an in-mold coating amount of 1.2 cubic inches would produce a full in-mold coating shot and

cover the entire plaque. As can be seen from the chart, upon in-mold coating injection onto the plaque surface, the top left panel and the inside vertical panel (runner section A) were preferentially coated when 25% of a full shot was utilized. Thus, this example shows that Section A is an effective runner section whereby the coating prefers to flow down the plaque along Section A and out to the side thereof before flowing into thinner sections B, C, and D. When 50% of a full in-mold coating shot was utilized, the in-mold coating began to flow from Section A and B into Section C. It is important to note that the plaque shown in FIG. 9 does not contain an in-mold coating containment flange. When coating levels above 50% of a full shot were utilized, the same leaked or seeped out of the mold cavity through the parting line. Thus, the need is clearly shown for an in-mold coating containment flange in order to keep the in-mold coating on the desired substrate surface. It has further been shown by the example that preferential coating of preferred or runner sections of a plaque can be obtained by utilizing the thickness of the wallstock to guide the in-mold coating across the part surface.

20 Example 2

FIG. 10 shows a thermoplastic article with a variety of substrate (thermoplastic) thicknesses. It was shown through experimentation that in-mold coating flow is influenced by the

substrate thickness. The example parts were generated using a 50-ton injection molding machine, a 6-inch square steel mold cavity fitted with an IMC injection nozzle. The substrate material was a PET thermoplastic and the in-mold coating was OMNOVA's Stylecoat® IMC. The mold temperature was 250°F with a 30 second delay time prior to IMC injection.

In FIG. 10, sections E, F, and G are representations of varying part thickness as shown by the chart below. Section H represents the in-mold coating tab design utilizing a thicker middle section which facilitates an in-mold coating flow channel at the in-mold coating nozzle tip site. Section I represents the thin sectioned containment flange.

The overall objective in designing a mold with thin and thick sections is to preferential channel the in-mold coating flow path in a desirable fashion. This can be manifested in several ways which include:

1. A channeling of the in-mold coating flow at the in-mold coating tab site (Section H) which preferentially deposits the in-mold coating inside the mold parting line onto the surface of the part.
2. A channeling of the in-mold coating flow in the part to more critical areas to fill since selective in-mold coating may be necessary in certain article designs (Sections E, F, and G).

3. A restriction of in-mold coating flow along the periphery of the mold to contain the in-mold coating on the surface of the part and within the parting line (Section I).

The observed in-mold coating coverage for the 6x6 mold is as

5 follows:

% of full IMC Shot	Section E % Fill/mils*	Section F % Fill/mils*	Section G % Fill/mils*	Section H % Fill/mils*	Section I % Fill/mils*
50	100/3	80/2	20/1	100/2	0/0
80	100/4	100/3	40/2	100/3	0/0
100	100/4	100/3	100/3	100/4	0/0

Note: Section E = 115 mils (thickness)
 Section F = 85 mils
 Section G = 60 mils
 Section H = in-mold coating tab - 60 mils
 Section I = containment flange - 25 mils
 * 1 mil = 0.001 inch

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In the example(s) we have shown that this preferential flow mechanism has advantages which include:

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1. Preferential IMC flow and deposition to selected regions on a part as a result of varying thickness.

2. Achieving the containment of IMC on the part surface within the parting line resulting from a designed thin sectioned, IMC flow restricting, "containment flange."

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In accordance with the patent statutes, the best mode and preferred embodiment have been set forth, the scope of the

invention is not limited thereto, but rather by the scope of the attached claims.

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What is claimed is:

1. An in-mold coated substrate comprising:
 - a. a substrate having at least one area of increased dimensional thickness relative to at least one adjacent area; and
 - b. an in-mold coating on a show surface of said substrate so that said substrate area of increased dimensional thickness is preferentially coated relative to said substrate area without increased dimensional thickness.
2. A substrate according to claim 1, wherein said substrate includes an in-mold coating containment flange situated about at least a portion of a perimeter of said substrate which prevents said in-mold coating from leaking through a parting line of a mold cavity.
3. A substrate according to claim 2, wherein said flange has a thickness less than a thickness between said show surface and a second surface substantially opposite said show surface.
4. A substrate according to one of claims 2 or 3, wherein said flange has a sufficiently minimal thickness in a plane offset from the show surface, so that said in-mold coating is substantially prevented from leaving the show surface and coating the flange.
5. A substrate according to one of claims 2-4, wherein said show surface is substantially covered with said in-mold coating, and wherein said flange is substantially free of said in-mold coating.

6. A substrate according to one of claims 1-5, further including an in-mold coating injection inlet area, said inlet area located in an area of said substrate where an in-mold coating is injected onto said substrate, said inlet area having at least two different thicknesses to channel flow of said in-mold coating onto said surface.
7. A substrate according to claim 6, wherein said inlet area is a tab which includes a thick central portion and a relatively thin outer perimeter which partially surrounds said thick central portion.
8. A substrate according to claim 7, wherein said relatively thin outer perimeter is an in-mold coating containment flange which substantially is a flow barrier to said in-mold coating.
9. A substrate according to one of claims 6-8, wherein at least one runner section extends on said substrate from said in-mold coating injection inlet area to a predetermined end location.
10. A substrate according to claim 9, wherein said at least one runner section is an area of increased thickness on said substrate relative to at least a second area on said substrate.
11. A substrate according to one of claims 9 or 10, wherein said in-mold coating is substantially located on said substrate surface in the area of said runner section.

12. A substrate according to one of claims 1-11, wherein said substrate is a thermoplastic.
13. A substrate according to one of claims 1-12, wherein said in-mold coating is a thermosetting acrylic composition.
14. A method for promoting preferential flow of an in-mold coating on a substrate comprising the steps of:
- a. forming a substrate, said substrate having at least one area of increased dimensional thickness relative to at least one adjacent area; and
 - b. coating said substrate on a show surface thereof with an in-mold coating so that said substrate area of increased dimensional thickness is preferentially coated relative to said substrate area without increased dimensional thickness.
15. A method according to claim 14, wherein said substrate includes an in-mold coating containment flange situated about at least a portion of a perimeter of said substrate which prevents said in-mold coating from leaking through a parting line of a mold cavity.
16. A method according to one of claims 14 or 15, wherein said at least one area of increased dimensional thickness is a runner section which promotes flow of said in-mold coating to said coated portion.
17. A method according to claim 16, wherein at least one of said at least one runner sections extends on said substrate from said in-mold coating injection inlet area to a predetermined end location.

18. A method according to one of claims 14-17, wherein said substrate includes an in-mold coating injection inlet area, said inlet area located in an area of said substrate where an in-mold coating is injected onto said substrate, said inlet area having at least two different thicknesses to channel flow of said in-mold coating onto said substrate.
19. A method according to claim 18, wherein said inlet area is a tab including a thick central portion and a relatively thin outer perimeter which partially surrounds said thick central portion.
20. A method according to one of claims 14-19, wherein said substrate is formed by molding the substrate between at least two separable mold members which form a closed mold cavity therebetween at a temperature and a pressure sufficient to form the substrate, said mold cavity having areas of varying thickness which allow said molded substrate to have areas of varying thickness.

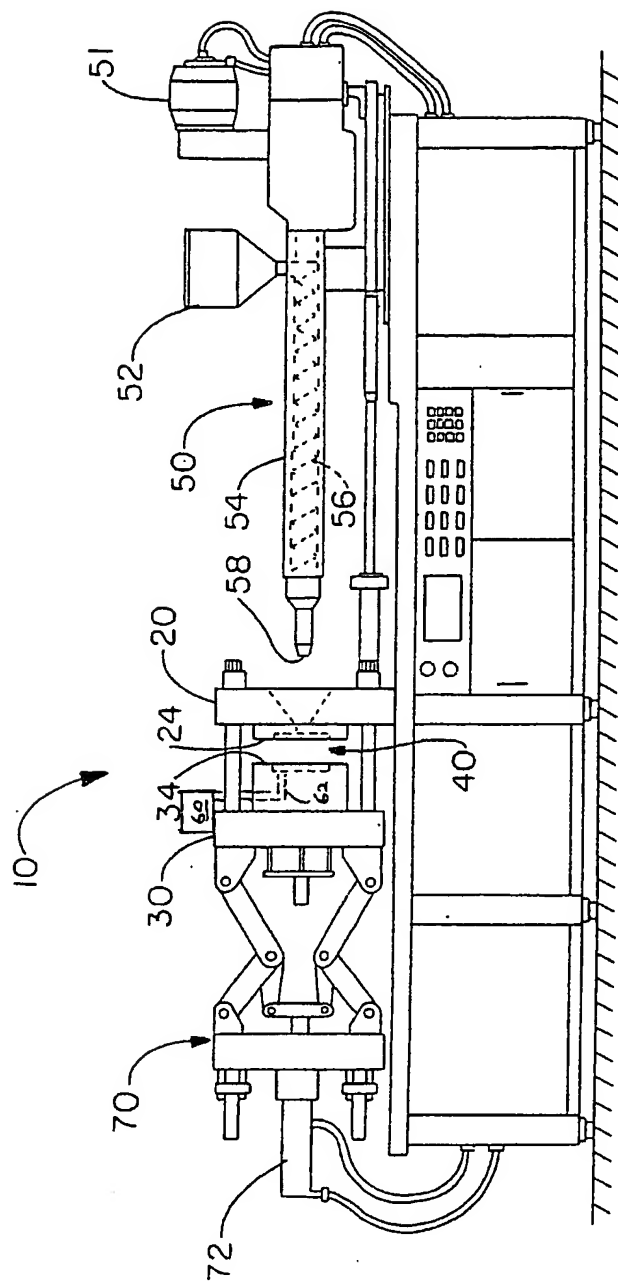
AMENDED CLAIMS

[received by the International Bureau on 20 February 2003 (20.02.03);
claims 1, 2 and 14 amended; claims 3 - 13 added claims 15 - 20 unchanged (2 pages)]

What is claimed is:

1. An in-mold coated substrate comprising:
 - a. a substrate having at least one area of increased dimensional thickness relative to at least one adjacent area, said area of increased dimensional thickness positioned to facilitate the efficient coating of a show surface of said substrate; and
 - b. an in-mold coating on said show surface of said substrate including said substrate area of increased dimensional thickness wherein said substrate area of increased dimensional thickness is preferentially coated relative to said at least one adjacent area because said in-mold coating tends to flow toward areas with relatively increased dimensional thicknesses as a result of increased compression thereof.
2. A substrate according to claim 1, wherein said substrate includes an in-mold coating containment flange adjacent said show surface and situated about at least a portion of a perimeter of said substrate which prevents said in-mold coating from leaking through a parting line of a mold cavity.
3. A substrate according to claim 2, wherein said flange has a thickness less than a thickness between said show surface and a second surface substantially opposite said show surface.
4. A substrate according to one of claims 2 or 3, wherein said flange has a sufficiently minimal thickness in a plane offset from the show surface, so that said in-mold coating is substantially prevented from leaving the show surface and coating the flange.
5. A substrate according to one of claims 2-4, wherein said show surface is substantially covered with said in-mold coating, and wherein said flange is substantially free of said in-mold coating.

12. A substrate according to one of claims 1-11, wherein said substrate is a thermoplastic.
13. A substrate according to one of claims 1-12, wherein said in-mold coating is a thermosetting acrylic composition.
14. A method for promoting preferential flow of an in-mold coating on a substrate comprising the steps of:
- c. forming a substrate, said substrate having at least one area of increased dimensional thickness relative to at least one adjacent area; and
 - d. coating said substrate on a show surface thereof with an in-mold coating, said show surface including said substrate area of increased dimensional thickness which is preferentially coated relative to said substrate area without increased dimensional thickness as a result of increased compressibility of said area of increased dimensional thickness.
15. A method according to claim 14, wherein said substrate includes an in-mold coating containment flange situated about at least a portion of a perimeter of said substrate which prevents said in-mold coating from leaking through a parting line of a mold cavity.
16. A method according to one of claims 14 or 15, wherein said at least one area of increased dimensional thickness is a runner section which promotes flow of said in-mold coating to said coated portion.
17. A method according to claim 16, wherein at least one of said at least one runner sections extends on said substrate from said in-mold coating injection inlet area to a predetermined end location.



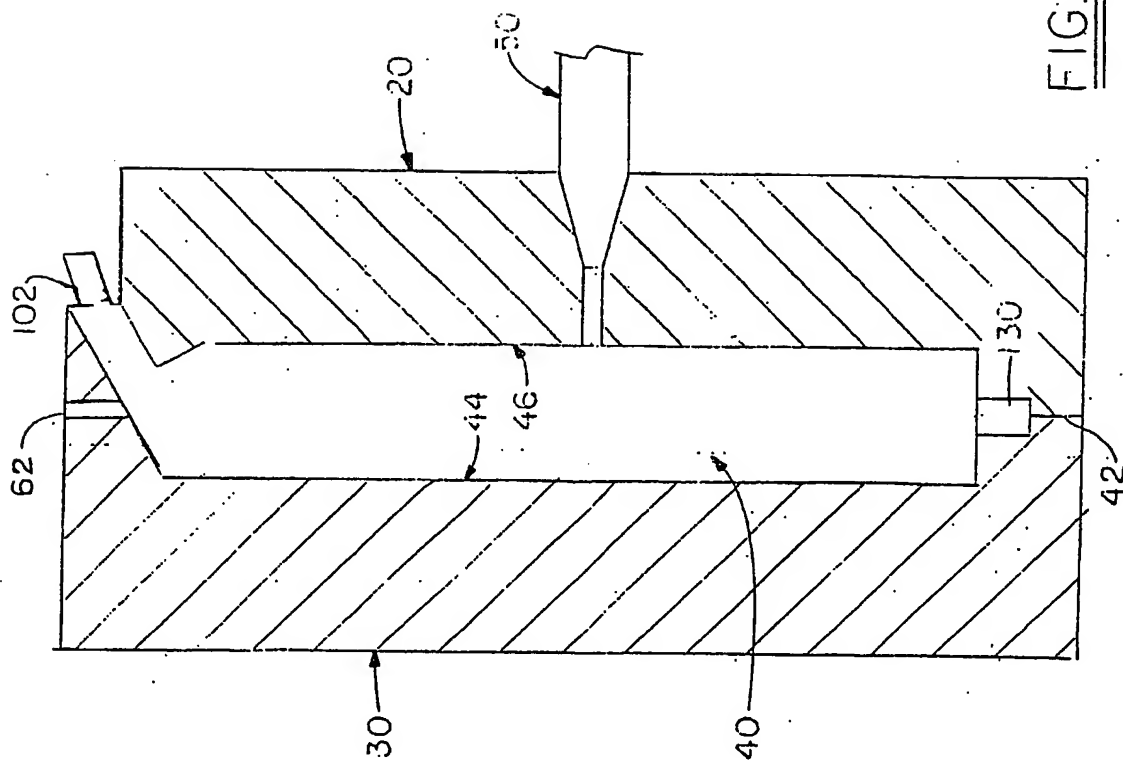


FIG. -2

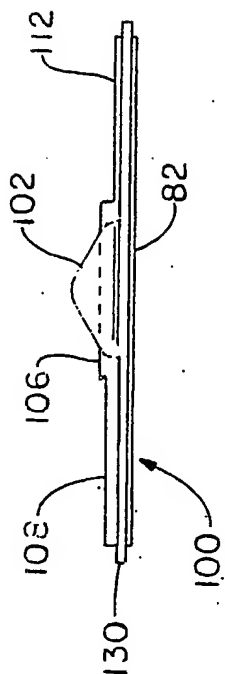


FIG. -3

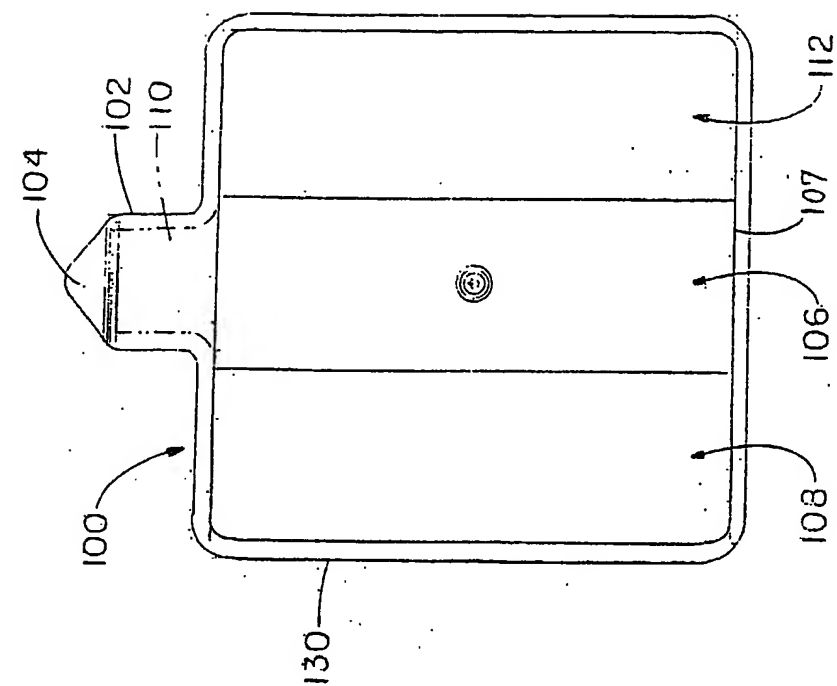


FIG. 4

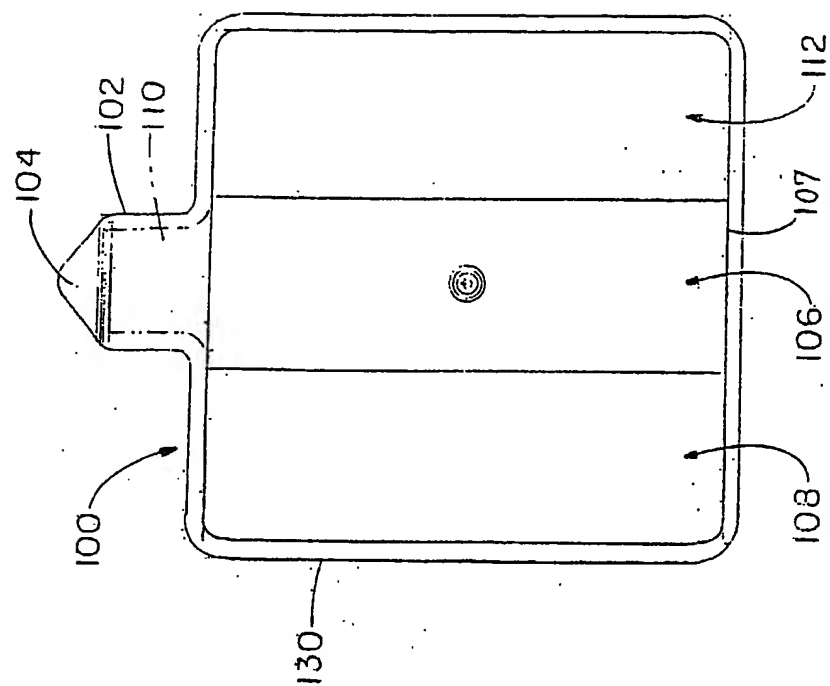


FIG. 5

FIG.-6

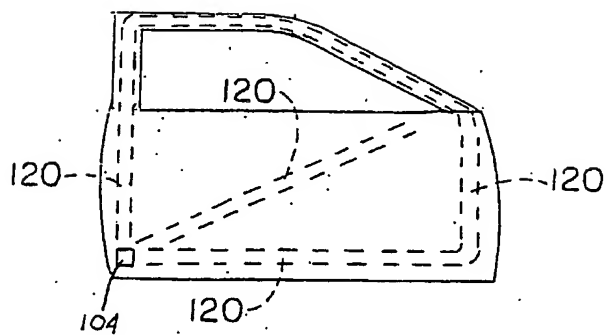


FIG.-7

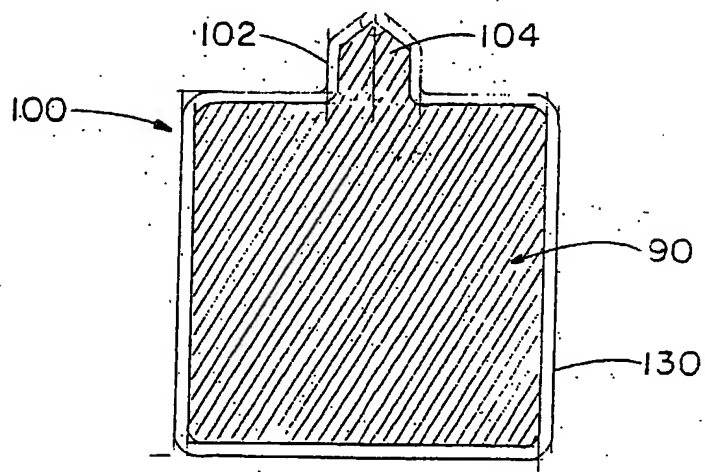
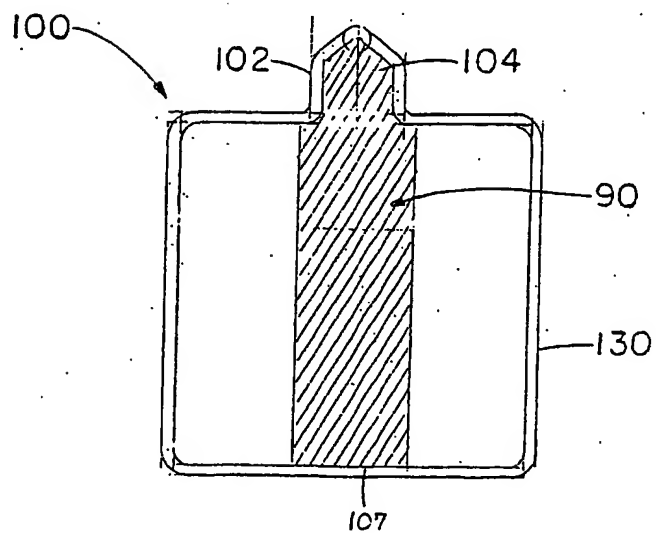


FIG.-8



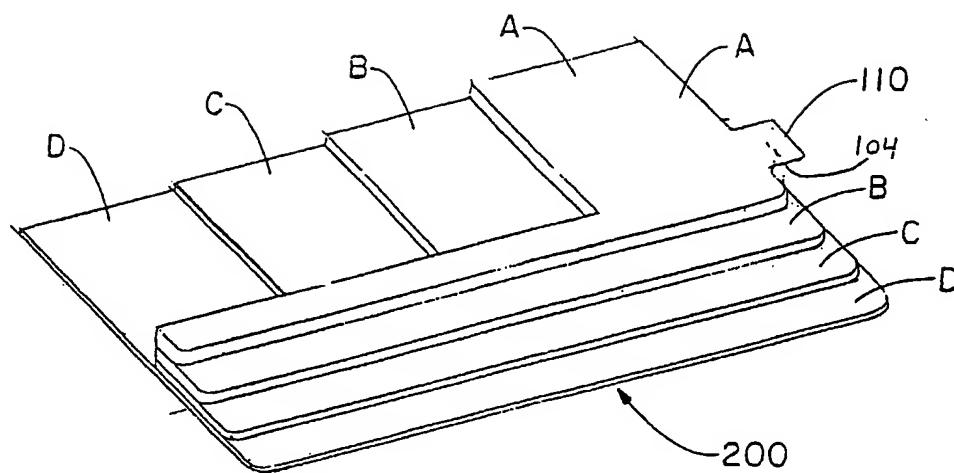


FIG. -9

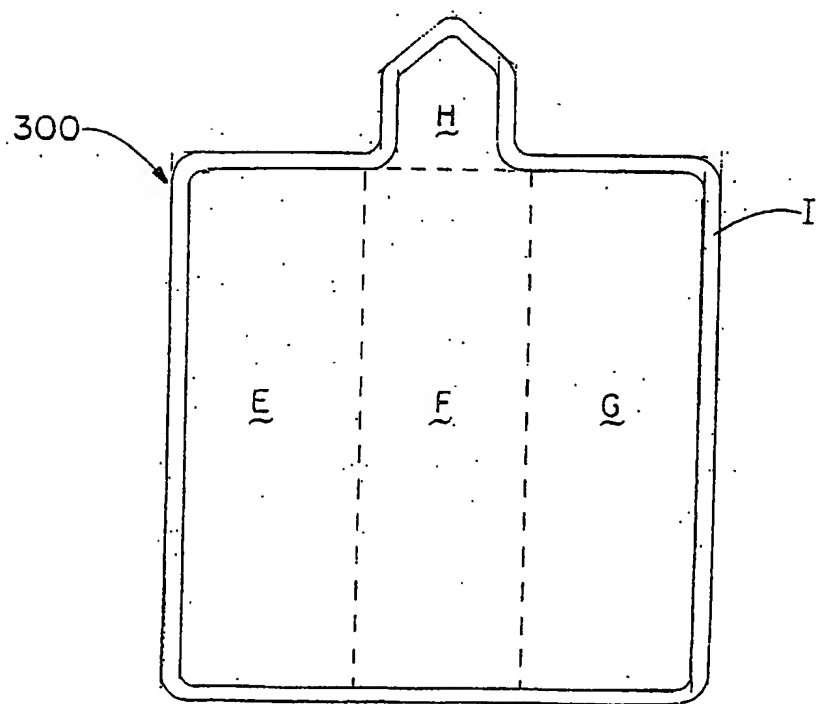


FIG. -10

INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/US 02/33757

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C37/00 B29C45/16 B32B27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

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-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the International search

10 December 2002

Date of mailing of the International search report

20/12/2002

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INTERNATIONAL SEARCH REPORT

Int. Application No
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